Power Flow Analysis of Integrated Wind and Solar Power Generation and Distribution System

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***Abstract* --- Power flow analysis is also known as load flow analysis in which per unit voltage and magnitude of the system is analyzed by the MI POWER SOFTWARE using the Newton Naphsion method. Which is faster on the speed of convergence, but programming is more complex suitable for large size system and the number of iterations does not depend on the size of the system, extra retention memory or remembrance is essential. The power flow is not unable to combine parts in power system analysis the main factor incite is the inability regards the power system to meet the demand for reactive power voltage instability does not always occurs in its pure form. A distinction between angle stability is important for understanding the underlying determinant concerning the problem in order to develop appropriate design and operating procedures**

Keyword --- Load flow analysis; Newton Raphsion method; Extra retention memory; Reactive power voltage instability.

I. INTRODUCTION

Load flow analysis can be carried out for small and medium size power systems. It suits for the radial distribution system with high R/X ratio. The load flow analysis helps to identify the overloaded/underloaded buses in the system. It is used to study the optimum location of capacity is and their size to improve unacceptable voltage profile Power flow analysis or load flow analysis is performed in a symmetrical steady-state operating condition of a power system under the normal mode of operation. The solution of load flow gives bus voltages and line/ transformer power flow for a prone load condition. This information is essential for long-term planning and operational planning. In the network of the power system, buses become node and a voltage can be specified for each bus. Load flow analysis is essentially concerned with the persistence of complex bus voltages at all busses, given the network configuration and the bus demands. The bus generation and characterized by complex powers flowing into and out of the buses respectively. A generation inventory is nothing but a combination of MW generation of the various generations should match the given requirement plus the transmission losses. It should be noted that there are many generation schedules available to match the prone system demand and one such schedule is chosen for load flow analysis is Newton Raphsion method

II. CLASSIFICATION OF BUSES

The following information is essential for long term planning and operational planning.

A. Long-term Planning

Load flow analysis helps in investigating the effectiveness of alternative plans and choosing the perfect plan for system expansion to meet the projected operating state.

B. Operational planning

It helps in choosing the perfect unit commitment plan and generation schedules to run the system efficiently for the next day's load condition without contravening the bus voltages and line flow operating limits.

C. *Steps for load flow analysis*

The following work has to be carried for a load flow study. Representation of the system by single line diagram.

- Decisive impedance design diagram using the information in the single line diagram
- Formation of network equation
- Solution of network equation

The buses are classified based on the variable specified. There are three types of buses.

1. Slack bus or swing bus or reference bus.
2. Generator bus or voltage bus or P-V bus or regulator bus.
3. Load bus or P-Q bus.

The following table gives the quantities specified and the quantities to be specified for each bus

Table I.

S.No	Bus	Quantities Specified	Quantities to be Specified
1.	Slack Bus	$\lvert V \rvert$, δ	P, Q
2.	P-V Bus (or) Generator Bus	P, $\lvert V \rvert$	Q,δ
3.	P-Q Bus (or) Load bus	P,Q	$\lvert V \rvert$,δ

At these buses, the active and reactive power are specified, the magnitude and phase angle of the voltage are unknown. These are called as load bus

Advantages of load flow analysis

In the power system design and operation there are four things that need to be understand

D. Slack Bus

In slack bus, voltage magnitude and phase angle of voltages are specified pertaining to a generator bus usually a large capacity generation bus is chosen. We assume voltage (V) as reference phasor

I.e., $\delta = 0$

Where δ = Phase angle of voltage.

This bus makes up the difference between the scheduled load and generated power that are caused by the losses in the network.

The power balance equation is

$$P_L = \sum_{i=1}^{N} P_i = \sum_{i=1}^{N} P_{Gi} - \sum_{i=1}^{N} P_{Di}$$

P_L depends on I^2 R loss in the transmission line and transformer of the network. The individual current in the various lines of the network cannot be calculated until after the voltage magnitude and angle are known at every bus of the system. Therefore, PL is initially unknown. Real and reactive power is not specified for slack bus. In power flow problem,we assume one generator bus as a slack bus at which power generation is Prespecified. After the power flow problem has been solved, the difference between the total specified real power going into the system at all the other buses and the total power consumed by loads plus I^2 R losses are assigned to the slack bus. Therefore a generator bus must be selected as the slack bus. The slack bus is needed to account for transmission line losses.

E. Generator bus or P-V bus or Regulated bus

At these buses, the real power and voltage magnitude are specified. The phase angle of the voltage and the reactive power are also specified.

In order to maintain a good voltage profile over the system, Automatic Voltage Regulator (AVR) is used.Static VAR compensator buses are called as buses because real power and voltage magnitude are specified at these buses

F. *Load* Bus or P-Q Bus

- Load (Types of Load, demand and forecast).
- Protection

G. Calculation of Resistance and reactance of system

The Formula to find Resistance (R)

$$R=\frac{\rho L}{A}$$

Where

ρ= Resistivity

L = Length

- Generation (Type, capacity,forecast and others too)
- Distribution network

A = cross section area

At 300 metre Resistance R = 0.3021 Ω

At 400 metre Resistance R = 0.402 Ω

At 200 metre Resistance R = 0.201 Ω

At 50 metre Resistance R = 0.0503 Ω

H. The Formula to find Reactance

$$X=X_L - X_C$$

Where

$$X_C = \frac{1}{2\pi f c}$$

$$X_L = 2\pi fL$$

The Formula to find Inductance

$$L=2l\left[ln\left(\left(\frac{2l}{d}\right)\left(1+\sqrt{1+\left(\frac{d}{2l}\right)2}\right)\right) - \sqrt{1+\left(\frac{d}{2l}\right)2}+\frac{\mu}{4}+\left(\frac{d}{2l}\right)\right]$$

Where

d = Diameter

l =length

At 300 m Inductance L = 0.000688H

At 400 m Inductance L = 0.000939H

At 50 m Inductance L = 0.0000966H

At 200 m Inductance L = 0.000442H

Formula for cylindrical Capacitor

$$C = \frac{2\pi\varepsilon o L}{ln\left(\frac{b}{a}\right)}$$

At 300 m capacitance C = 0.0677μF

At 400 m capacitance C = 0.0810 μF

At 50 m capacitance C = 1.01293×10^{-8} μF

At 200 m capacitance C = 0.04006 μF

Reactance of 300 m 0.1638

Reactance of 400 m 0.2556

Reactance of 50 m 0.28363

Reactance of 200 m 0.05933

III. SINGLE LINE DIAGRAM

A single line diagram is a diagrammatic representation of power system in which the components are represented by their symbols and the interconnection between them are shown by a single straight line (even though the system is a three phase system). The ratings and the impedance of the component are also marked on the single line diagram

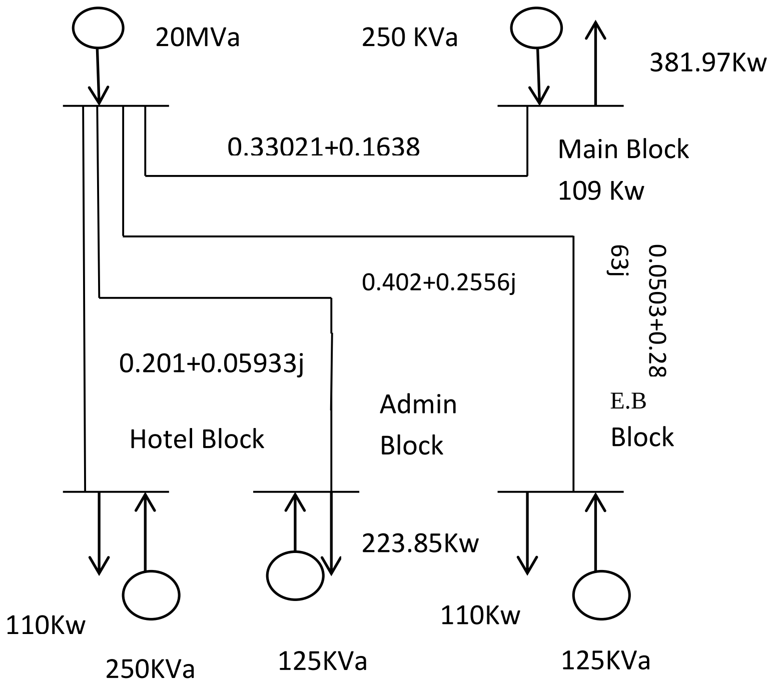

Fig. 1. Power system Network

The scope of the single line diagram is to supply in concise form of the significant information about the system. The power system network is represented by one line diagram using suitable symbols for generator, motor, transformer, transmission line and loads.

A. *Impedance diagram*

The impedance diagram on the single phase basis under balanced operation conditions can be drawn from one line diagram

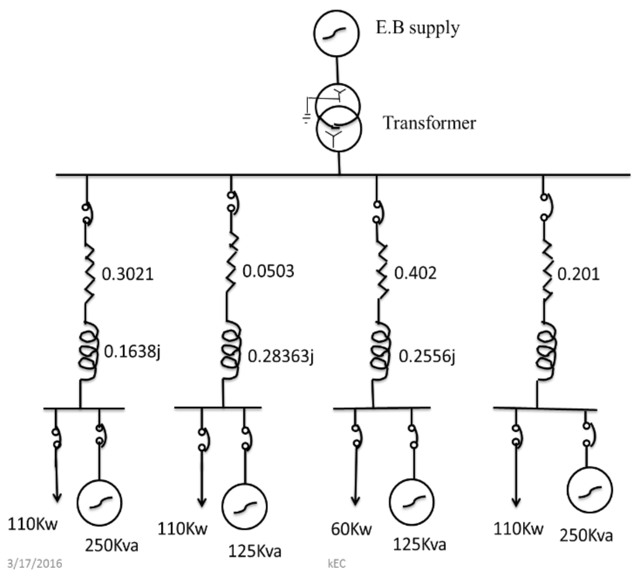

Fig. 2. Single Line Diagram

- Single phase transformer equivalents are shown as ideal transformers with transformer impedance indicated on appropriate side.
- Magnetization reactance of the transformers have been neglected.
- Generator are represented as voltage sources with series resistance and inductive reactance

B. *Steps to draw per unit impedance diagram*

- Choose a common MVA or base MVA for the system (Mostly highest generator rating is taken).
- Choose an appropriate base KV for each and every section

C. *Applications of Y bus matrix*

- Y-bus is used in solving load flow problems.
- It has gained applications owing to the simplicity in data preparation
- It can be easily formed and modified for any changes in the network
- It reduces computer memory and time requirements because of sparse matrix

Y bus is determined by Two-rule method or inspection method.In the equivalent network generators are replaced by Norton's equivalent, the load is replaced by equivalent admittances and the lines replaced by π-equivalent circuits.

IV. LOAD FLOW ANALYSIS RESULT

Load flow analysis is done through newton Raphsion method

Version number: 8.2

%% first power system network

The Largest bus number used	: 8
Actual number of buses	: 8
Number of 2 wind. Transformer	: 2
Number of Transmission lines	: 5
Number of Loads	: 4
Number of solar plants	: 1
Number of Generators	: 2
Base MVA	: 50
Nominal system Frequency (Hz)	: 50
Maximum number of iterations	: 15
Bus voltage below which load Model is changed	: 0.75
Transformer R/X Ratio	: 0.05
Annual percentage interest charges	: 15
Annual percent operation &	: 4
Life of equipment I years	: 20
Maintenance charge	

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Table I. Bus Data

BUS NO.	AREA	ZONE	BUS KV	VMIN (P.U.)	VMAX (P.U)	NAME
1	1	1	0.415	0.95	1.05	BUS 1
2	1	1	33.0	.95	1.05	BUS 2
3	1	1	0.69	0.95	1.05	BUS 3
4	1	1	0.415	0.95	1.05	BUS 4
5	1	1	0.415	0.95	1.0	BUS 5
6	1	1	0.415	0.95	1.05	BUS 6
7	1	1	0.415	0.95	1.05	BUS 7
8	1	1	0.415	0.95	1.05	BUS 8

Table II. Transformer Data

STATUS RATING	CKT	FROM NODE	TO NODE	IMPEDENCE	
				R (P.U.)	X(P.U.)
				MINTAP	MAXTAP
3	2	2	3	0.005	0.11765
				0.95	1.05
3	2	2	1	0.10618	2.12357
				0.91051	1.00635

Table III. Transformer Data

STATUS RATING	CKT	FROM NODE	TO NODE	NOMINAL TAP	
				TAP	MVA
				TAPSTEP	SHIFT-DE
3	2	2	3	0.00588	0.11765
				0.95	1.05
3	2	2	1	0.10618	2.12357
				0.91051	1.00635

Table IV. Transmission line data

CKT	FROM NODE	FROM NAME	TO NODE	TO NAME	RATING MVA	
					R(P.U)	X(P.U)
1	4	Bus4	1	Bus1	17.88360	10.2560
1	1	Bus1	5	Bus5	17.88360	10.62560
1	1	Bus1	6	Bus6	17.88360	10.62560
1	1	Bus1	7	Bus7	17.88360	10.62560
1	1	Bus1	8	Bus8	17.88360	10.62560

A. NO OF ITERATION

Iteration count 0 maxp 0.00200 max 0.002945

Iteration count 1 maxp 0.00003 max 0.000022

Iteration count 2 maxp 0.0000 maxq 0.0000

Iteration count 3maxp 0 .0000maxq 0.00000

Iteration count 4 maxp 0.0000 maxq 0.003894

Itertion count 5 maxp 0.00002 maxq 0.000035

- The N-R method is faster, more reliable and the result are accurate
- Required less number of iterations for convergence
- The number of iterations are independent of the size of the system
- Suitable for large size systems.

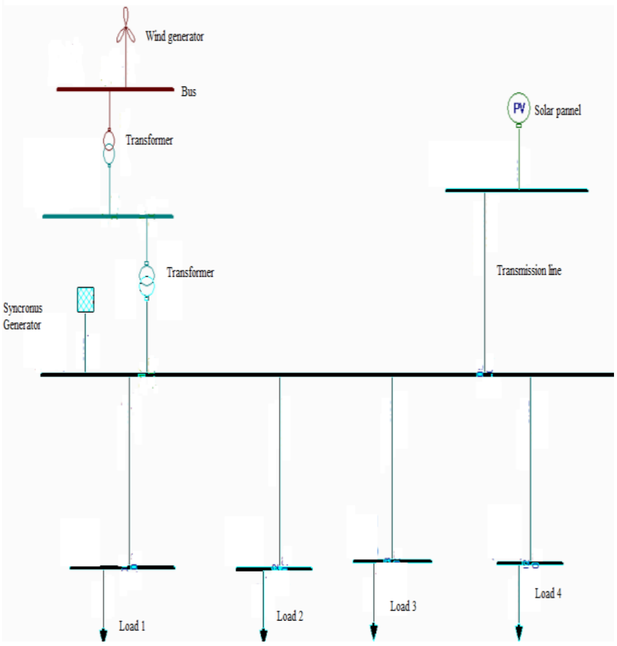

Fig. 3. Simulation Single Line Diagram

Table V. Bus voltage and Powers

Node No	From name	V-Mag P.U	Angle degree	MW GEN
1	BUS1	1.0000	0.00	-0.017
2	BUS2	1.0088	0.24	0.000
3	BUS3	1.0089	0.25	0.100
4	BUS4	1.0209	0.27	0.050
5	BUS5	0.9716	0.18	0.000
6	BUS6	0.9885	0.07	0.000
7	BUS7	0.9835	0.1	0.000
8	BUS8	0.9885	0.07	0.000

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Table VI Bus voltage and Powers

Node No	From name	MVAr GEN	MW LOAD	MVAr LOAD
1	BUS1	0.031	0.000	0.000
2	BUS2	0.000	0.000	0.000
3	BUS3	0.052	0.000	0.000
4	BUS4	0.016	0.000	0.000
5	BUS5	0.000	0.053	0.040
6	BUS6	0.000	0.022	0.017
7	BUS7	0.000	0.031	0.024
8	BUS8	0.000	0.022	0.017

Table VII. Transformer Flow And Transformer Losses

Sl. No	CS	FROM NODE	FROM NAME	TO NODE	TO NAME	FORWARD	
						MW	MVAr
1	1	2	BUS 2	3	BUS 3	-0.100	-0.052
2	1	2	BUS 2	1	BUS 1	0.100	0.052

Table VIII.Transformer Flow And Transformer Losses

Sl. No	CS	FROM NODE	FROM NAME	TO NODE	TO NAME	LOSS	
						MW	MVAr
1	1	2	BUS 2	3	BUS 3	0.0	0.00
2	1	2	BUS 2	1	BUS 1	0.0	0.0005

Table IX. Line Flows And Line Losses

Sl. No	CS	FROM NAME	TO NAME	FORWARD		Loading
				MW	MVAr	
3	1	BUS 4	BUS 1	0.050	0.016	60.3
4	1	BUS 1	BUS 5	0.055	0.041	80.4
5	1	BUS 1	BUS 6	0.022	0.017	32.5
6	1	BUS 1	BUS 7	0.032	0.024	46.6
7	1	BUS 1	BUS 8	0.022	0.017	32.5

V. SUMMARY OF RESULTS

Total real power generation
(CONVENTIONAL) : 0.00 MW
Tolal reactive power Generation (CONVENTIONAL)
:0.083 MVAr
Toal real power generation (WIND)
:0.100Mw
Total reat. Power generation (WIND)
:0.052MVAr
Total real power generation (WIND)
: 0.050 MW
Total reat. Power generation (SOLAR)
:0.052MVAr

Total real power load : 0.129MW
Total real power drawal(-ve gen) : 0.017MW
Total reactive power load : 0.097MVAr

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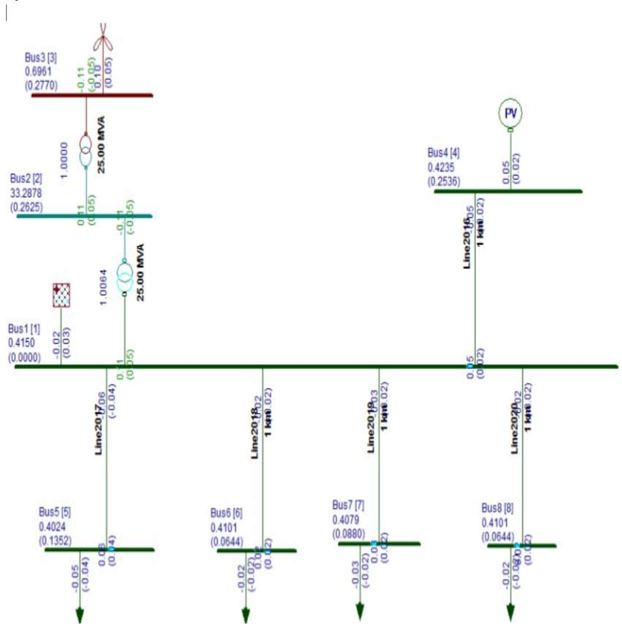

Fig. 4. Output of Simulation Single Line Diagram

Load p.f : 0.8
Total real power loss(AC+DC) : 0.003790 MW (0.003790+0.0000)
Percentage real loss (AC+DC) : 2.527
Total reactive power loss: : 0.002800MVAr

A. Zone Wise Distribution Description

MW generation : -0.0174
MVAr generation : 0.0312
MW wind gen. :0.1
MVAr wind gen. :0.0517
MW solar gen. :0.0500
MVAr soalr gen. : 0.0164
MW load : 0.1288
MVAr load : 0.0966
MW loss : 0.0038
MVAr loss : 0.0028

VI. CONCLUSION

From the power flow analysis of a given system optimized power flow stabilized which is having 0.1 MW of generation from wind and 0.5MW of generation from solar to the grid connected system of 20 MW of synchronous generator generation. The corresponding voltage and magnitude are stabilized through reactive power compensation and obtianted per unit voltage of given system is also stabilized.

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